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**Army Maintenance Prospects
for Materiel Readiness**

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by

Martin F. Brooks
Charles A. Bruce
Conway J. Christianson
Gerald E. Cooper
Richard G. Huver
Joseph J. Minor
John G. Phillips
Harry D. Sheets



RESEARCH ANALYSIS CORPORATION
6935 Arlington Road, Bethesda, Md., Washington 14, D. C.

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RESEARCH ANALYSIS CORPORATION

6935 Arlington Road

Bethesda, Md.

FOREWORD

This paper describes in broad terms a future maintenance concept. It is not purported to be a final product as it represents only a quick look at many maintenance and repair-parts supply problems. The suggestions need more study and consideration.

The ideas set forth did not originate with the authors. Instead they are ideas growing out of many discussions with individuals, both within RAC and the Army. Although the ideas need to be further developed and tested, the paper will have served its purpose if it arouses sufficient interest to generate further exploration.

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ARMY MAINTENANCE PROSPECTS FOR
MATERIEL READINESS

INTRODUCTION

This paper was originally prepared for the Army Tactical Mobility Review Board in June 1962 to synthesize the current experience of the Research Analysis Corporation on equipment maintenance studies. The periodic preparation of papers of this type is necessary to give broad direction to detailed studies that are largely concerned with the situation as it exists, not with how it should exist in another context. RAC has not conducted maintenance studies on all classes of Army equipment. For this reason action is not recommended until the following have been explored further, and tested:

- (a) That part of third-echelon maintenance that should be absorbed by organization maintenance.
- (b) Organization and operation of maintenance contact teams.
- (c) Division of work between direct and general support units and depots.
- (d) The economy and military desirability of depot rebuild as currently operated.
- (e) The stockage and distribution, particularly by air, of repair parts.
- (f) Improvement in maintenance by improved equipment design.

Comments or suggestions, particularly relating to possible errors or omissions, would be most helpful in ensuring the greatest possible use of data from current studies in the development of long-range policy.

BACKGROUND

Great changes are often predicted for the future Army without mention of probable future supply and maintenance posture. Groups at RAC and elsewhere are pursuing programs that affect the design of tomorrow's tactical and tactical-support systems. To be effective, any "new look" in support must be consistent with a great variety of sound support principles. However, many of these principles often lead in contradictory directions. The selection of an appropriate system is both a serious and difficult compromise. This paper iterates many factors that cannot be ignored. Not all are yet reducible to quantifiable terms and, even for those that are reducible, no adequate method exists to evaluate all their interactions. The general problem currently stands fragmented among the research attacks on many subareas. Each such limited approach runs the risk of missing the mark with respect to what someday will be the supply-maintenance master plan.

In this paper, current maintenance policies and some results of recent analyses are evaluated and reviewed to provide suggestions for advanced (a) maintenance policies, (b) repair-parts supply procedures, and (c) overhaul and replacement policies consistent with changing equipment readiness requirements.

Today any mention of the tactics of the future is an invitation to discuss increasingly fluid operations. The concept of continuous front lines that prevailed in the two world wars is being superseded by tactics placing higher premiums on mobility. The tactics envisioned subdivide the combat force into relatively small, semi-independent elements, deployed in greater depth and often with considerable distance between units.

Enemy penetration and infiltration will be a constant hazard to the dispersed combat formations. Much of the time, supply and service elements may have to face risks to their local security. The threat of nuclear destruction suggests that these units also be dispersed. In the field army the opposing needs of security and dispersion may compel the setting up of a series of autonomous, small-scale supply and service field facilities, i.e., "junior depots," instead of a consolidated giant installation. Each facility must be capable of defending itself, furnishing supplies, and performing maintenance on all types of equipment (engineer, ordnance, signal, etc.). If one installation were destroyed, others would have to absorb the work load, at least temporarily.

The greater tactical and administrative self-sufficiency, already assumed for future combat units, must extend into the areas of supply and maintenance. Even with a reasonably secure support system, the enemy might interrupt the line of communications. Although the existence of both air and ground communications would increase the probability that at least one of these two means could be used to provide a minimum of logistical service, units would at times have to be prepared to carry on without support.

THE PRESENT MAINTENANCE ORGANIZATION

The Army describes their maintenance system as having five echelons: first and second echelons are organizational maintenance; third and fourth echelons are field maintenance; and fifth echelon is depot maintenance. However, in order to meet changing maintenance demands, this system reflects adjustments of the originally assigned activities and responsibilities of the various echelons. The evolutionary changes that have taken place have been more the result of expedients than an overall appraisal of the entire system.

In the past, maintenance units behind the front lines were reasonably secure and could select locations primarily on the basis of where they could best serve their customers. In a theater-sized operation this permitted maintenance dispositions in width and depth that would maximize cross-support and backup capabilities. The suitability of this type of maintenance organization and disposition must be reexamined in the light of changing tactics and anticipated changes in customer needs.

TRENDS THAT AFFECT MAINTENANCE PROBLEMS

Increasing Mechanization of Combat Units

A trend toward greater mechanization has added more vehicles (both ground and air), as well as other types of equipment to combat units and has

added to the maintenance workload. Also, equipment is generally becoming more complex, requiring more sophisticated maintenance support.

Restrictions must exist on the amount and type of maintenance that may be performed on equipment at organizational and field maintenance levels. However, as long as the number of supported items continues to grow, any restrictions on allocated skills, parts, and tools must be subject to continual review. Conflicting requirements make this a difficult problem. Care must be exercised to avoid overloading the unit's maintenance activities with parts and tools to the point that the unit's mobility is impaired. On the other hand, without a capability to handle the majority of equipment failures, unit effectiveness would rapidly deteriorate. Most organizational maintenance shops have greater skills and capabilities than maintenance allocation directives permit them to employ. In emergencies they can and have done much more than they are presently authorized to do. An increase in authorized capability is entirely consistent with minimum augmentation of personnel, parts, and tools.

No unit will be self-sufficient for very long without some organic maintenance insurance factor. The chances of obtaining replacement equipment under the future's presumed tactical conditions appear remote. Successful evacuation of major end items and major assemblies seems equally unlikely. Therefore equipment that fails during an operation will have to be repaired on the spot, towed along for repair at the first opportunity, or abandoned. It is expected that a unit will often have to complete its mission with the equipment with which it started; reequipping will probably occur only when the unit is withdrawn and sent to a rear area. Under these circumstances the tactical commander will always be reluctant to abandon any critical item. To preserve unit strength, equipment will have to be kept operable to the greatest extent possible, and, as long as there is a chance that an item can be reused, every effort will be made to save it. For these reasons the tactical commander will demand a maintenance capability that will reduce to a minimum his reliance on outside support.

Deadlined equipment places many demands on a combat unit. The Army's decisions regarding the evacuation of deadlined equipment have a direct bearing on formulation of the overall maintenance policy. Three major considerations that require evaluation are: (a) the combat unit's effectiveness while equipment is out of service, (b) the costs of evacuation, and (c) the expense of a replacement. These factors should be compared to the alternatives of repairing the equipment on the spot, which would involve (a) providing mechanics, tools, and parts; (b) their transport and other support; and (c) whether time and circumstances permit repair. Previous studies show that the efficiency of the production-line type of maintenance performed at higher echelons is offset by the transportation costs of evacuation and return. The end product may possibly be better, but a long-term quality advantage may be worth less than the time saved by a more rapid repair. Once a piece of equipment gets into the evacuation stream it is days if not weeks before the user can expect to get it back. In the meantime, in order to maintain unit equipment strength and operational readiness, a float end item must be provided, an expensive alternative. Only a minor portion of the time out of service is required for actual repair of deadlined equipment. For example, it was found that for some tactical communications equipment the ratio of transportation time to actual repair

time was 100 to 1. For wheeled and tracked vehicles the actual time in shop (greater than the actual repair time) was about one-third of the total time out of service.

Whereas in the past the relatively small number of items to be supported did not justify assigning special maintenance skills and special tools to the using unit, the situation is now changing. As the number of end items to be supported increases, there is greater justification for moving more of the special skills closer to the equipment. The number of vehicles currently assigned to an armored division, for example, results in the generation of enough unserviceable major assemblies to provide full-time employment for several assembly repairmen. (This work is now performed at fourth and fifth echelons.) As infantry divisions are mechanized, they too will generate greater numbers of unserviceable assemblies. It may be feasible to reduce the equipment in the maintenance pipeline by adding manpower, parts, and tools close to the principal sources of unserviceables, the combat units themselves, but again the problem of balancing end-item and repair resources arises. More repairmen and fewer end items may cost no more than less repairmen and more end items, but overall effects are likely to be very different.

Use of Maintenance Contact Teams

The Army is utilizing increasing numbers of maintenance contact teams--specialists who go to the equipment instead of having the equipment evacuated to them. These specialists perform "road service" and repair on site. In many instances this has been an effective technique.

Some repair can best be done on site; some can best be done in a special shop; much work could be done in either location. Whether or not the "either . . . or" category should be assigned to contact teams remains debatable. Dead-lined equipment, equipment in transit, and mechanics in transit are all non-productive. The repairman driving or flying to his next job is the picture of mobile maintenance, but when he is in a well-equipped shop he gains versatility. All-around mechanics; fast transport; light, small diagnostic and repair equipment; and parts availability are all necessary for successful use of contact teams. In addition to their capability to perform on site, effective contact teams can provide a skilled specialist pool that can be shifted from shop to shop to meet peak workloads.

In garrison it is not unusual for a customer unit to share a building or equipment park with its supporting unit. Then the maintenance resources are no more than a few yards from "on site." A mistakenly selected part can be exchanged easily, and specialist advice can be called on freely. During peacetime the advantages or disadvantages of contact operations become apparent only during exercises or maneuvers.

As with other military tasks, tremendous advantage can accrue to the commander who has the right maintenance resources at the right place at the right time. Contact teams may provide a valuable path to greater maintenance advantage, but substantial analysis must precede their full employment. The teams offer the prospect of great flexibility of movement; whatever their design, they must retain diversity of skills.

Component Replacement

The replacement of assemblies and subassemblies has become one of the chief means of restoring end items to serviceability at organizational and field maintenance levels. Defective components, although often repairable, may be replaced immediately in order to reduce the total down time of the parent item, the number of lines stocked at that shop, diagnostic difficulties, and demands for special repair skills.

Much electronic repair equipment is built of modules. Quick component replacement is one objective of electronic modularization, although other motives, including overall size and weight reduction, may at times be the prime concern. Many new electronic modules are less expensive than programs for their repair would be; many of these have been classed as throwaways, and, as long as replacements remain available, defectives are to be replaced but not repaired.

Tanks are designed so that their power packs (engine plus transmission) can be removed and installed in a relatively short time; in effect power packs themselves are modules. In turn an engine or a transmission may also be considered modular. The sheer weight and bulk of such "mechanical modules" present evacuation, repair, and supply problems differing from those of electronic assemblies. The choice between repair and replacement involves many factors. Because of high initial cost, tank engines and transmissions are not likely to be viewed as readily expendable. These and other complex, expensive assemblies normally are repaired for stock. Whereas a small boy can carry many electronic modules, a truck must be used to carry a tank engine as far as a few feet. The location of a repairing facility greatly affects the size of assembly stocks, supporting parts, and the total distances and tonnages moved.

The tactical situation and considerations of initial expense, repair cost, performance, and transit time all influence the decision to repair or replace assemblies. Whatever the case, an unserviceable assembly cannot be replaced unless a serviceable one is available, and it cannot be repaired unless labor, tools, and parts are available. The conflict between the advantages of component replacement and likely limitations of supply transport space will have to be resolved through retention of piece-part supply for many items.

In light of anticipated future battlefield conditions, movement of supply vehicles will probably have to be made in convoy, and, depending on the situation, escort may be necessary. The expected difficulty and uncertainty of resupply dictates that only the most critical and essential items be carried. Supply vehicles should not be encumbered with heavy, bulky evacuation loads. Component and end items planned for evacuation and return should be limited to those that can be readily transported in supply vehicles and supply aircraft. The premium on space favors piece-part repair, provided the means and the time to effect the repair exist.

Repair-Parts Supply

The success of a maintenance system is tied to repair-parts supply. Many delays in the completion of repair jobs are attributable to unavailable parts.

Expanded stocks, more selective stocks, rapid delivery, cannibalization, and fabrication are all means of filling demands for parts. All have been tested and retested. Attempts to utilize each are reflected by the current system. The advantages of stocks that contain the needed and exclude the unneeded parts are obvious, but much more sensitive means of forecasting demands must be developed. Regardless of other features the successful system will have to include rapid delivery among its merits. The great number of parts essential to the proper functioning of equipment makes it unlikely that all demands can ever be met entirely from stock. Probability considerations serve to show that even judiciously selected stockages have a definite chance of being caught short. An unstocked part or more than the expected number of stocked parts may occur at an all too critical time. Thus at some time resupply may be expected to become a problem for even the best designed stockage system.

Local fabrication of parts does not seem to have been a chief source in the past and is expected to have limited use in the future.

The present requisitioning and delivery system has not been found to provide the short-term service its design predicted. Peacetime supply generally favors the economical approach and rarely resorts to more expeditious service. The relative difference in real expense of down time in peace and wartime can dictate vastly different economical systems. The summary observation is that current supply is sluggish through attempted economy; it can be speeded up at greater expense, but even then it does not appear capable of achieving the best expected of it.

The seeming successes of the priority ordering and delivery systems currently employed are not proofs of the adequacy of supply as a whole. Success with a portion of the inventory is bought with slippage elsewhere. It is inconceivable that the current priority systems can be expanded to include the majority of the inventory overnight.

Each major training exercise should be used as an opportunity to test the adequacy (items and quantity) of the basic load of repair parts and where they can best be carried. Parts consumption during these maneuvers should be thoroughly analyzed and the basic repair-parts loads adjusted accordingly.

Replacement and Overhaul Policies

The Army's policies for equipment replacement can have a significant effect on the overall maintenance support requirements. Studies of mechanical equipment conducted by RAC indicate that maintenance effort increases considerably as equipment ages and accumulates more usage.* At some point in the life of vehicular equipment the many minor repair jobs become a significant workload for the using unit, often saturating its capacity. The increased occurrence of major deficiencies also overloads the field maintenance echelon. The volume of these deficiencies begins to increase significantly at about the mid-life of a vehicle, seriously degrading equipment readiness and the combat capability of the fighting unit. Equipment should be removed from critical combat units before equipment unreliability grows to serious proportions.

*"Economics of Maintenance and Replacement of $\frac{1}{2}$ -, 2 $\frac{1}{2}$ -, and 5-Ton Truck Fleets (U)," Operations Research Office (Research Analysis Corp.), ORO-T-401, Sep 61; "Operation, Maintenance, and Cost Experience of the Tank, Armored Personnel Carrier, and Self-Propelled Howitzer Fleets (U)," Research Analysis Corp., RAC-T-409, Sep 62.

Two things can be done with unreliable combat equipment: (a) either replace it with new, or (b) perform thorough maintenance and return it to the user. The former action is preferred because RAC studies showed that equipment, even after overhaul, is considerably less reliable than new equipment.

Replacing equipment in priority combat units before the total life of the equipment has been extinguished will not increase the procurement budget when secondary uses for the equipment can be found. There are usually sufficient lower-priority requirements (such as training, service and supply functions, etc.) to use up the remaining life of the equipment. In these secondary roles the fact that equipment is less reliable and demands more maintenance effort is not nearly so critical.

The Army's recently announced tracked-vehicle replacement and maintenance policy is a step toward earlier removal of unreliable equipment from high-priority combat unit. With the precedent once established, it is expected that in the near future it will be a general practice to rotate equipment from front to rear, the newest equipment (if not new, at least the better equipment) being issued to the combat forces. An overall policy such as this would be desirable, because it not only maximizes the equipment-readiness status of the combat elements but also provides an economical, satisfactory way of extracting the remaining useful life out of the equipment. It is to be remembered though that the type of equipment (new, old, or overhauled) issued to any using unit directly affects that unit's supply and maintenance burden.

Equipment withdrawn from combat units should be given thorough maintenance before it is issued for a secondary task (or reissued to combat troops if this is necessary). The purpose of this repair would be to correct existing deficiencies and also to perform preventive maintenance in order to improve reliability. Specifically this preventive maintenance should replace or repair all the parts that past experience indicates are likely to cause trouble, such as water hose, wiring harness, etc. Organizational maintenance is usually able to correct only the existing deficiency, with little opportunity to diagnose and anticipate failures and correct them before they are likely to occur. It is felt that this work can best be accomplished at some installation toward the rear, where time and facilities can permit a more thorough job.

This suggested replacement policy is consistent with the maintenance organizational structure proposed earlier in this paper. The using organization would continue to do whatever is possible to keep equipment in a high state of availability and dependability; when the time comes that they are no longer capable of doing this, the equipment would be evacuated to base maintenance for a thorough reconditioning prior to reissue to a training or support unit.